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ABSTRACT

The development of distance education will be shaped by technological, demographic, economic, and political forces, as well as by pedagogical insights from its practitioners. Technology-mediated interactive learning (TMIL), a new form of instruction, may result from the synthesis of distance education, cooperative learning, and computer-supported cooperative work. Group process themes and cooperative learning may be increasingly incorporated into distance learning classrooms, which can be designed to promote a wider, deeper range of student skills than a local site could offer, afford a higher quality of teaching than may be locally available, and provide greater opportunities for students to interact. As distance education evolves to technology-mediated interactive learning it will become the preferred instructional methodology instead of simply a means of providing solutions to conventional teaching problems. (25 references) (DB)

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The Evolution of Distance Learning: Technology-Mediated Interactive Learning

A Report for the Study: "Technologies for Learning at a Distance"
Science, Education, and Transportation Program
Office of Technology Assessment
Congress of the United States

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This report has two primary goals. One objective is to provide provocative ideas on how emerging forces external to education may shape the future of distance learning. The second purpose is to depict a potential new field, technology-mediated interactive learning, that may result from the synthesis of distance learning, cooperative learning, and computer-supported cooperative work.

The sections below are sequenced as follows. First, the major technological, demographic, economic, political, and pedagogical forces driving the evolution of distance learning are described. Second, a probable outcome of these advances is depicted: the emergence of technology-mediated interactive learning (TMIL) as a major form of instruction. Then, illustrative, paradigmatic research shaping the development of TMIL is discussed. Finally, as distance learning evolves into TMIL, its likely cognitive, emotional, and maturational effects are briefly assessed.

This think piece is suggestive of what may occur rather than providing a rigorous forecast and assessment. Through analyzing interacting trends and discontinuities external to conventional distance learning, a better sense can be gained of how this field may expand beyond its roots. In general, new technologies are initially used to accomplish existing objectives more efficiently through traditional methods; for example, primitive distance learning involves conveying a screen image of conventional classroom instruction to learners at remote sites. Only with experience do users recognize that advances in technology offer the potential for accomplishing new objectives more effectively in innovative ways. The ideas below reflect my current vision of distance learning's long-term potential for improving education.

FORCES DRIVING THE EVOLUTION OF DISTANCE LEARNING

The development of distance learning will be shaped by external technological, demographic, economic, and political forces, as well as by pedagogical insights from its practitioners. Over the next decade, how will each of these impact the distance learning movement?

TECHNOLOGICAL ADVANCES

For at least another fifteen years, the information technologies will continue to rapidly increase in power while decreasing in cost. This will have two major effects on distance learning: the synthesis of computers and telecommunications, and the growing affordability of sophisticated technology for instruction.

Synthesis Devices

Greater power coupled with the advance of fiber optics is driving the emergence of new devices that synthesize the historic capabilities of computers and telecommunications (1). Vendors are realizing that customers want technologies combining functionalities of the telephone, television, copier, printing press, radio, and computer. As an illustration, fax machines are currently popular; they incorporate attributes of scanners, computers, telephones, and printers. Synthesis devices are being potentiated by four interacting developments: miniaturization, standardization, the universality of digital code for interconnecting traditionally separate technologies, and the declining cost of processors powerful enough to coordinate complex information flows.

The trend toward synthesis is a major reversal in the evolution of information technology. In the past, each technological breakthrough created new "species" in the "ecology" of information technologies (e.g. multiple formats of videotapes; mechanical videodiscs; optical videodiscs; read-only multi-media optical discs; write-once, read-many optical discs). The result has been confusion on the part of both suppliers and consumers: What ecological "niche" will this product fill, and with what existing species will it compete? What format will emerge as the new (temporary) standard? How will this emerging technology interconnect to existing devices?

Now, while advances are constantly occurring, merging technologies mean that the number of species in the ecology is shrinking rather than growing. Synthesis devices are attractive to both vendors and consumers as a turnkey method for utilizing technology without worrying about the questions delineated above. Eventually, only a few highly integrated technologies may remain as "information utilities," and the computer may seldom be seen as an isolated device (2).

Merging technologies are of great importance to distance learning because the advanced instructional functionalities discussed later in this study depend on devices that combine the capabilities of computers and telecommunications. The immediacy of video interaction greatly enhances instruction, as does the ability of the computer to simulate, instruct, entertain, and analyze (3). Historically, however, coupling a set of telecommunications systems to a cluster of computer devices has been prohibitively complex and expensive. Synthesis technologies offer an eventual resolution to this problem. However, these sophisticated devices will still be more expensive than either computers or

telecommunications in isolation, so the installed base of current instructional technologies will continue to be used for many types of learning even after synthesis devices become available.

Growing Affordability

A second major effect of advances in information technology on distance learning is the decreasing cost of powerful information technologies. To illustrate how rapid these changes have been, a decade ago $3500 could buy an Apple II™ microcomputer, two 140K disk drives with controller, and a Radio Frequency Modulator to connect this system to a television set. Adjusting for ten years of inflation, an equivalent amount of purchasing power today is $6800. For that price, one can buy a Macintosh II™ with a microprocessor that can handle data sixty-four times faster, twenty times the internal RAM and ROM memory, two 1.4 Megabyte (M) disk drives and an internal 80M hard disk, and a display included--with seven times the resolution and sixteen times the number of colors. Comparable figures can be cited for computers from other vendors and for other types of information technologies (e.g. videocameras, copiers, printers).

These increases in capability are crucial to the evolution of distance learning because sophisticated pedagogical functionalities require large amounts of memory and power. The coming generations of instructional applications--embedded intelligent coaches, easy-to-use interfaces that mimic the natural environment, artificial realities, real-time interaction of multiple users--necessitate inexpensive hardware to be cost-effective (4). Fortunately, within a decade the equivalent of today's supercomputers will be available at personal computer prices.

DEMOGRAPHIC FORCES

Distance learning is a strategy educational institutions are initially using to overcome inadequacies of local resources for meeting learners' needs. This rationale for distance learning is steadily becoming more important as shifts in immigration and family structure widen the range of student characteristics. The ethnic, linguistic, and cultural diversity of the American population is increasing because of a move away from the "melting pot" orientation that typified the assimilation of past generations of immigrants and minorities.

Simultaneously, the typical childhood has altered: In 1955, sixty percent of American families matched the "Beaver Cleaver" model--working father, housewife mother, two or more school age children. Now, only seven percent of families fit this pattern, and no dominant family structure has emerged as a

replacement (5). Children today are growing up with a very wide spectrum of socialization experiences, socioeconomic backgrounds, and adult and peer role models; the range of personal needs and cognitive/affective styles they bring to learning situations is correspondingly expanding.

As these trends continue, an increasing number of educational institutions will experience difficulty in providing resources to match students' widening needs. Distance learning will be seen as an important method for pooling instructional capabilities in response to the growing pluralism of learners' backgrounds and characteristics. Illustrative advantages distance learning can offer over conventional classroom instruction in responding to the growing diversity of learners are:

- students with an unusual learning need (e.g. Thai as their primary language) can be pooled into a class of sufficient size to fund the cost of a specialized teacher
- courses in atypical subjects (e.g. Japanese) can be offered by accumulating pupils from a number of districts
- students with visual learning styles can benefit from the multi-media format of distance learning
- learners dealing with unusual emotional problems (for example, incest) can form support/counseling groups in which the technology allows greater exposure of feelings without the risks of direct personal contact

Thus, distance learning can aid with problems of scale (not enough students in a single location), rarity (an instructional specialty not locally available), and cognitive and emotional style.

By creating connections between diverse groups of students, distance learning can aid in resolving America's emerging shift from assimilation to pluralism. Our nation is now more a "salad bowl" than a "melting pot," and this internal diversity could potentially be a great competitive advantage in the global marketplace. However, some students in relatively homogeneous geographic regions will not have classmates of different cultural, linguistic, ethnic, and socioeconomic backgrounds--unless they have distance learning experiences. The deliberate use of distance learning technologies to overcome students' segregation into homogeneous enclaves could help prepare the next generation of workers for the worldwide business environment they will face.

ECONOMIC FORCES

As American corporations use advanced information technologies to compete in the global marketplace, the industrial environment in current organizations will gradually transform to a workplace built on cognitive partnerships between people and intelligent, knowledge-based tools (6). One characteristic of this shift will be the growing importance of teams--rather than individuals--in accomplishing tasks. The mixture of multiple specializations requisite for solving complex, real world problems increasingly necessitates a group pooling its intellectual resources; no "renaissance individual" can hope to keep pace with today's accelerating advances.

This expansion of group activities as a proportion of work can pose major problems of sustaining productivity. While in well-functioning teams a collective intelligence emerges that is more than the sum of its parts, in many groups a "lowest common denominator" effect predominates. Without careful guidance and support, aggregations of individuals can easily bog down in a collective overhead of intellectual and emotional miscommunication. All types of organizations increasingly have a strong interest in building their employees' strengths in teamwork.

Moreover, geographic and temporal barriers are emerging as a major impediment to the functioning of these working groups. Developing a new product for a multinational corporation may require a task force composed of a designer in Sweden, a manufacturing engineer in Japan, a marketing expert in India, and a financial specialist in the United States. For this team to be effective, bridges across distance and time must be created.

In response to these challenges, a field called computer-supported cooperative work (CSCW) is developing. As described later, CSCW centers on studying the nature of teamwork and on building tools that provide technological support for group functioning. CSCW's insights into collective processes may be valuable for education in general, given the growing interest in cooperative learning and situated learning (7).

In particular, the tools from CSCW that facilitate bridging geographic and temporal barriers will impact on the evolution of distance learning. Moreover, because of the economic shifts described above, all educational institutions may eventually be asked to produce students adept at distanced interaction. Skills of collaboration with remote team members will be as central to the future American

workplace as learning to perform structured tasks quickly was during the early stages of the industrial revolution.

POLITICAL FORCES

The educational reform movement in the United States is forcing changes in many traditional pedagogical practices. In particular, legislatures are mandating higher levels of performance outcomes from schools, including the provision of advanced courses (e.g. calculus, Chinese) for students desiring that knowledge. This poses a major problem for small or poorly funded districts, which have difficulty generating the internal resources to fulfill instructional requirements for low enrollment classes and for fields with shortages of qualified teachers.

The economic trends just discussed will intensify these challenges. As technological costs for the long-range delivery of instructional services decline, distance learning will be an increasingly important strategy these districts can use to respond to external requirements for their range and depth of offerings. In addition, as skill at distanced interaction becomes more central to workplace activities, political pressures on educational institutions to provide distance learning situations may rise even when districts can afford traditional single-classroom instruction for all subjects.

PEDAGOGICAL FORCES

A final impetus to the evolution of distance learning will come from within education rather than externally: Instructors are recognizing the effectiveness of learning at a distance. In particular, second and third generation distance learning projects are moving beyond accomplishing traditional objectives efficiently to using emerging technologies in effectively empowering new goals and innovative pedagogical methods. Distance learning classrooms can be designed to have a wider, deeper range of student skills than a local site could offer; a higher quality teacher than a single district could afford; and, as discussed later, greater opportunities for students to interact than traditional single-classroom settings. Eventually, distance learning may be the preferred delivery system for certain types of instruction, rather than a fall-back approach to be used when conventional teaching strategies are not feasible.

An important equity consideration in implementing distance learning is making its benefits available to the entire student population, rather than only to gifted pupils who need a specialized course not offered locally. As discussed earlier, both the growing diversity of the student population and the importance of

pluralistic experiences as preparation for the global marketplace make distance learning an attractive option for all pupils. Adoption strategies should stress open access to this type of instruction.

TECHNOLOGY-MEDIATED INTERACTIVE LEARNING

This study argues that the probable outcome of these interacting technological, demographic, economic, political, and pedagogical forces is the emergence of a new field: technology-mediated interactive learning (TMIL). TMIL is likely to evolve from the synthesis of distance learning, cooperative learning, and computer-supported cooperative work. A major reason that group process themes may be increasingly incorporated into traditional distance learning is the centrality of cooperative interaction in the successful bridging of geographic and temporal barriers. In any type of instruction--conventional classroom or distance delivery--the emotional dimension is as important as the cognitive. Similarly, individual learning is always situated in a group context, whether students are face-to-face or in a virtual environment.

COOPERATIVE LEARNING IN DISTANCE LEARNING

To accomplish effective distance learning, a cooperative relationship among the instructor and all the students must first be established. This cooperation involves multiple dimensions, including bonding emotionally, establishing a shared purpose, and developing common practices of interaction and communication. These affective and psychosocial aspects of distance classrooms are similar to the team building activities that underlie the emerging corporate focus on group work.

For example, studies of scientific research collaborations across barriers of distance and time depict a series of relationship-level task stages (8):

- finding a partner
- sharing background information
- establishing a division of labor
- building trust
- sustaining progress
- determining division of credit

Similar issues are important in distance learning settings and must be resolved through evolving cooperative relationships based on both cognitive and affective interaction.

Successful distance instruction depends on more than classroom management strategies, knowledge of subject matter, pedagogical expertise, and

the ability to use the technology. Creating an intellectually and emotionally attractive "telepresence" and building "virtual communities" of learners are also vital. Bill Cosby, Captain Kangaroo, and Mr. Rogers are adept at conveying their humanity to viewers--even though their actual presence in the home is only as a two-dimensional pattern of phosphorescent dots on a television screen. Media stars are skilled at developing communities of fans, who share a common bond of knowledge and vicarious experience through immersion in the same programming. In distance learning, selecting personable teachers and displaying students' photographs when they are speaking are early methods of developing this type of interaction, but more powerful strategies for building telepresence would enhance pupils' motivation and sense of community.

ADVANCES IN COOPERATIVE LEARNING

Both through research on situated cognition and through case studies of group "learning-by-doing," educators are increasingly realizing the power of cooperative learning approaches. This pedagogical strategy is very effective because students simultaneously experience 1) the active construction of knowledge; 2) peer teaching, with its opportunities for building oral explanation skills; 3) peer learning, with exposure to good models for problem solving and social interaction; and 4) the motivating feedback of other students.

However, cooperative learning approaches are underutilized in traditional classrooms because instructors often have concerns about:

- the difficulties of organizing and managing students in small groups
- the maturity and motivation of students in a peer teaching/learning situation
- our society's competitive paradigm stressing individual, rather than group, achievement

Most teachers have little preparation in pedagogical strategies to overcome these potential problems, such as forming groups heterogeneous in ability and characteristics; developing shared leadership and collective responsibility for individual learning; teaching collaborative skills to groups; and making team goals interdependent, but holding individuals accountable for performance (9).

Cooperative learning is likely to become more common in classrooms because of the growing use of instructional computing. Collaborative student groups aid in overcoming two weaknesses of the computer: They reduce the social isolation of learning from a machine and provide extrinsic motivation

through peer approval. The computer also facilitates organizing and managing cooperative learning: It provides a motivating, complex focus for the group; gives immediate feedback on team ideas; and mediates communication among team members.

This mediation of communication in the group is important for several reasons. Students may not understand a concept well enough to verbally explain it, but can communicate their ideas visually ("look at this") or through accomplishment ("watch what I'm doing")--if a shared medium for display and action is available. Computer-aided instruction designed for cooperative learning can provide such a medium; examples are the "Envisioning Machine" work at UC--Berkeley (10) and the "Earth Lab" project at BBN Labs (11).

DEFINING TECHNOLOGY-MEDIATED INTERACTIVE LEARNING

As ideas from cooperative learning and computer-supported cooperative work increasingly are incorporated into distance learning, a new field--technology-mediated interactive learning--may emerge. The fundamental characteristics of TMIL are:

- a technological medium either interposes between direct person-to-person interaction or provides a shared environment that shapes the process of interpersonal communication
- the technology provides tools and experiences that enhance the collective learning of the people involved, as well as their individual accomplishment
- the human participants' interaction is spontaneous

At one extreme, this definition would encompass several students interacting face-to-face about a technology-created experience tailored for team learning. At the other end of the spectrum, TMIL would include a group of geographically and temporally separated learners communicating through instructionally oriented computer conferencing; the Virtual Classroom project at the New Jersey Institute of Technology (12) and the InterCultural Learning Network (13) are examples. Outside of this definition would be non-spontaneous situations (e.g. a learner interacting with an instructional designer's knowledge through preprogrammed software) or linkages in which the technological medium had no special capabilities for collaborative learning (such as a telephone conversation between students).

ILLUSTRATIVE, PARADIGMATIC DEVELOPMENTS IN TMIL

TMIL would combine two current instructional capabilities--transcending geographic barriers (distance learning) and creating flexibility in time (virtual classrooms)--with three additional functionalities from computer-supported cooperative work:

- aiding teamwork (tools for collaborative problem solving)
- reducing information overload in group communications (intelligent agents)
- enhancing psychosocial interaction (organizational interfaces)

Early CSCW research has centered on computer-aided design, project management, group decision support, and electronic mail and computer conferencing applications. The major theories underlying this field come from linguistics, psychology, sociology, and anthropology.

Examining CSCW research is important for two reasons. First, some ideas powerful in improving occupational productivity may also enhance effectiveness in educational settings. Second, within a decade, the structure of groupware will be influential in shaping the cognitive, affective, and normative quality of working life, thereby determining the attributes educators will be asked to instill in students. The fundamental ideas underlying CSCW and their potential applications to distance learning are briefly described below.

DEVELOPING SHARED MENTAL MODELS

CSCW research on building shared mental models focuses on four types of interactions: organizing the ideas of a team, structuring group interchange and decision making, capturing the rationales for choices, and coordinating team activities. Systems capable of facilitating these group processes must have several types of features not needed in software applications oriented to improving the performance of individuals. Implementing these features requires that all participants in the group have workstations that are networked together so that information can be rapidly passed back and forth

The first feature essential for group work is a window on the screen that presents the same information to all team members. This is called a "What You See is What I See" (WYSIWIS) interface, an analogy to the "What You See Is What You Get" (WYSIWYG) interface typical of advanced text editing systems. Any number of group members can simultaneously alter information in the WYSIWIS window, and everyone's image of this shared information will be updated immediately.

In a meeting, when a person points to an item on his WYSIWIS screen, the other team members may not be able to see where he is pointing. A "telepointer" is a second feature central to group work that resolves this problem. The telepointer symbol (usually an arrow) appears in each person's WYSIWIS window. Any group member can move the telepointer to indicate an item, and all members of the group will be able to see what is happening. The screen interface is "direct manipulation," which allows group members to move icons like the arrow by clicking on them and dragging them with the mouse (similar to the Macintosh interface).

Direct manipulation interfaces, which mimic the physical properties of the real world, are not only easy to learn, but also take advantage of human "motor memory" capabilities. People can remember complex material better if its different chunks are grouped in spatially related locations. For example, when using a blackboard, we place similar ideas in physical proximity; people can even remember material that has been erased if someone points to its long-gone location on the board. The physical attributes of direct manipulation interfaces perform a parallel function in helping groups use motor memory to organize complex material.

A third useful feature is the capability of CSCW software to automatically save the dynamic contents of each participant's windows. This provides an easy mechanism for electronically storing not only the final product of a group session, but also the detailed ideas and changes each individual evolved during the meeting. This rich record is much more useful that the single set of minutes generated in a non-electronic meeting; a secretary's notes capture only one person's perception of the outcome of the group session and omit many details of the final product's evolution.

A fourth frequent feature of CSCW software is hypertext capabilities. One way to represent a shared mental model is by joining related ideas (nodes) through arrows (links). Such an model mirrors in many ways the associative nature of human long-term memory, so groups find this type of representation easy to use. The web structure these nodes and links form can portray a very complicated set of ideas and interrelationships as a fairly simple screen image, but the detail underlying the nodes and links is not lost--it can be accessed by clicking on those icons. This is a powerful way of revealing and concealing complexity as the group builds an elaborate mental model.

A final major feature central to a team's building such a shared web of ideas is segmenting each type of group activity into stages, then developing a set of specialized information tools to aid group process in each stage. For example, a meeting might be called to resolve an argument that group members are having; the team must either reach a majority decision or "agree to disagree." Such a meeting could be divided into three phases: presenting the different points of view, debating the merits and demerits of each, and reaching a final decision. For this type of group session, special "arguing" software can be developed that gives participants useful tools for each phase of the meeting.

As an illustration, during the debating phase, a window on the screen could highlight some assumptions that different proposals share and other assumptions on which they disagree. This can help a group to clarify what an argument is really about and also keeps team members focussed on the same task rather than talking past each other. Without such tools, personal attachments to certain positions, unstated assumptions, and concealed criteria can be hidden factors that cloud processes of cooperation, compromise, and group decision making.

Thus, WYSIWIS interfaces, direct manipulation and telepointers, automatic electronic archiving, hypertext, and specialized software for different types of meetings are all useful features for building shared mental models. One example of a system with these features is the Colab project at the Xerox Palo Alto Research Center (14). Colab is an experimental meeting room set up to study how shared computational tools can enhance group problem solving in face-to-face interactions. In the future, many aspects of Colab may generalize to cooperative learning in classrooms.

Workplace tools for building shared mental models could easily transfer to distance learning. In face-to-face TMIL, multi-user WYSIWIS environments with direct manipulation, hypertext, archiving, and telepointers could support a motivating, complex focus; provide immediate feedback on ideas; and mediate group communication through vision and action. Also, dividing a learning activity into sequential phases and providing specialized tools that structure each segment is a powerful way to manage instruction. Many of these approaches for empowering face-to-face learning also generalize to virtual classroom situations in which students must overcome geographic and temporal constraints on communication.

COLLABORATING DESPITE BARRIERS OF DISTANCE AND TIME

CSCW research on overcoming limits of distance and time centers on building "organizational interfaces" (virtual environments common to all members of a working group). To date, the major applications developed have been oriented toward text sharing (electronic mail, computer conferencing), project management (task assignment, scheduling, logistics), and collaborative work without face-to-face interaction. As with groups building shared mental models, special system features are needed to facilitate this type of interaction.

One useful feature for bridging geographic and temporal barriers to teamwork is an intelligent agent that the user can program to filter and organize information. In an educational setting, such an agent could pre-process incoming electronic mail so that messages relating to different instructional projects were automatically grouped into their appropriate folders. The agent could automatically answer messages proposing meetings by using a scheduling system that accessed the electronic calendars of all group members.

An intelligent agent's capabilities for aiding work extend beyond responding to messages. Journals arriving in electronic form could be scanned by the agent for articles on educational topics of particular interest to the user, and that material automatically filed for future reading. Stewart Brand, in his book on the MIT Media Lab, depicts a similar "broadcatch" agent that would be built into home entertainment centers; it could scan cable channels and automatically prepare an evening's viewing of time-shifted programming (15). Such a system offers the potential for information-sharing between schools and homes: Teachers could send out detailed information on all students' performance, and parents could access--for their child--whatever portion of that data was of current interest. The burden of independently communicating individual pupil's progress to each family would be greatly reduced.

The Lens Project in the Sloan School of Management at MIT illustrates the use of these intelligent agents in a research setting. Lens incorporates a set of CSCW tools for managing electronic mail, computer conferencing, task tracking, and calendar management (16). As with Colab, many aspects of Lens are likely to appear in virtual classrooms as distance learning evolves.

Another useful feature in collaborating over distance and time is digital voice capability. Voice input allows users to freely express ideas without the necessity of typing, and voice output aids auditory learners. Moreover, this increased communication bandwidth is valuable for conveying shades of

meaning (such as ironic statements) and affective overlay (anger, dismay); these are quite difficult to express in purely textual messages. Two-way video would further extend the system's ability to convey subtle shades of meaning and a sense of social presence.

CSCW research on collaborating despite barriers of distance and time generalizes easily to distance learning situations. Virtual classrooms could be enhanced through organizational interfaces, message templates, intelligent computational agents, digital voice capabilities, and broadcatch functionalities; all are ways to expand the range of ideas and people with whom one could effectively communicate. Ultimately, these tools have the potential to create virtual educational communities in which TMIL is the primary method of interaction.

BUILDING SOCIAL INTERACTION THROUGH TELEPRESENCE

CSCW research on facilitating emotional bonding and social relationships centers on creating virtual environments similar to human communities. The major applications developed so far use video imaging and digital voice to widen the bandwidth of communication as much as possible, so that users can transfer face-to-face interaction skills into the technology-mediated context. However, while many aspects of virtual environments are similar to face-to-face encounters, the overall communications style needed to be effective in electronic interaction is fundamentally different.

Some reasons why the interchange of ideas in distance learning requires different communication methods than in conventional classrooms are:

- information technologies are predominantly a visual medium, rather than the textual and auditory environment of the conventional classroom
- the affective content of technology-mediated messages is muted compared to face-to-face interaction
- complex cognitive content can be conveyed more readily in electronic form because multiple representations of material (e.g. animations, text, verbal descriptions, visual images) can be presented to give learners many ways of understanding the fundamental concept

Good teachers in distance learning use different pedagogical approaches than they would in face-to-face interactions for the same reasons that a skilled actor would portray a role differently for a movie camera than for a stage audience.

The Cruiser project at Bell Communications Research and the Conversational Desktop project at the MIT Media Lab are two illustrative examples of work focused on exploring these subtle factors underlying telepresence. Cruiser is a multi-media vehicle for social browsing; the metaphor it builds on is the virtual corridor (21). This system uses office-based video cameras and software tools to create "proximity enhancers" that allow people in different locations to behave as if their offices were "just down the hall" from each other. Users at their workstations can image and browse a world with virtual corridors; one can view the interior of others' offices to see who is available that might help with a particular problem. Someone who temporarily wishes to be left undisturbed can draw their electronic "privacy blinds." Such situated cruising makes possible spontaneous, real-time exchanges among groups of people geographically separated, helping them to form and maintain working teams.

The Conversational Desktop prototype at the MIT Media Lab carries this idea still further; the computer becomes an intelligent partner in mediating human communication (22). This research is developing a system that provides both a communications web (like Cruiser) and a filter between the user and the social environment (similar to Lens). Each person in the Conversational Desktop group interacts with other team members through an intelligent device that recognizes speech, takes messages through digital voice input/output, filters phone calls, scans databases (weather, traffic, airport) to aid human planning, and schedules meetings.

In this system, users through their intelligent agents can exert a great deal of control over their social environment. As a illustration, the computer can be programmed so that, when a person is holding a meeting, some team members have sufficient priority to interrupt a user's face-to-face conversation with a telephone call, while others do not and must instead leave a message with the "phone slave." The intelligence, telepresence, and even "simulated personality" of each user's device creates some interesting value-laden issues in terms of what type of relationship to establish with a socially aware machine. The Conversational Desktop pushes the limits of how far people might choose to go with virtual working communities.

CSCW research on telepresence is important for distance learning. As discussed earlier, technology-mediated instruction requires emotional bonding and team building among teacher and students, not just cognitive exchanges. Learning is affective--not just cognitive; situated in a human environment--not

decontextualized; driven by motivational readiness--not just by receiving stimuli through the senses. Because they enhance social presence as well as facilitate information exchange, proximity enhancers, virtual corridors, situated cruising, natural language input/output, telepresence, and intelligent agents are all promising modalities to increase the effectiveness of distance learning.

EMOTIONAL AND MATURATIONAL SHIFTS CREATED BY TMIL

The reader may feel uneasy at this point, wondering what the long-range interpersonal effects may be of the advanced technologies this study describes. Little is known about the affective and social effects of sustained technology-mediated learning, and research into this topic is only now beginning. The provision of dedicated funding for evaluative studies of issues like telepresence would be an important role the federal government could play in advancing our ability to assess these technologies.

Informally, I can speculate about some likely positive and negative effects of TMIL. As an example of beneficial outcomes, I suspect that time-shifting communications (as occurs in computer conferencing systems for virtual classrooms) will increase the involvement of many learners who do not function well in conventional classroom settings:

- students who are less adept socially can use the limited bandwidth of textual communications to interact more effectively with others
- pupils who are shy can be more expressive, given the privacy and relaxed pace of mediated communication
- people who are less assertive or who are methodical can formulate responses at their leisure, rather than competing with others who jump in the instant a speaker has finished talking
- students who are quite emotional can temper their immediate responses by waiting to send replies
- people who wish to skim the messages of others rather than read in detail can do so (saving considerable time over the forced listening to an entire communication that takes place in real-time verbal interaction)
- all users can benefit by being able to communicate simultaneously, rather than being limited to the sequential "air-time" dictated by face-to-face interaction

- all users will enjoy the comfort, convenience, and access of interacting from their individual environments, rather than gathering at a common place of minimum mutual inconvenience
- all users will maturationally benefit from exposure to a wider range of cognitive, linguistic, cultural, and affective styles than they would typically encounter from a purely local group of fellow students

Research that establishes which (if any) of these speculative outcomes actually occur will be valuable in the design of future virtual environments.

This discussion of positive outcomes is not to suggest that everyone will like virtual environments more than conventional classrooms or that face-to-face educational interactions will largely disappear. Students congregate for instruction for many more reasons than that their teacher and desks are in a particular location. Similarly, forecasts that telecommuting would replace traveling to the office have so far greatly overestimated the potential of electronic cottage industries because they underestimated the emotional and social aspects of work. For each individual, understanding the optimal balance between direct and virtual interaction in learning and working situations will be important.

I can also hypothesize potential negative outcomes from technology-mediated communication. As an illustration, intelligent agents that filter social interactions can create the following types of business problems:

- a user may not wish to attend all meetings for which someone else would like to schedule him, necessitating hidden calendars that reflect a greater willingness to meet with some team members than others
- a person may resent being given a lower priority than a colleague to interrupt with a phone call a team member's face-to-face conversations
- a team member may be very disturbed if he finds that a group member's intelligent agent has been instructed to dump his messages unread (however valid that assessment may be)

Similarly, the real reason why a design decision has been made (e.g. a particular person may not capable of teaching a complex course) may be politically unfeasible to document for open inspection. People may use intelligent agents to filter their environment so effectively that they are never exposed to new ideas. I may not always want to interact with someone else's personality

simulator--at times I might prefer a stupid answering machine. Certainly, I will occasionally want to leave my desk and walk around, even if I can instead stay put and wander in a virtual world. Unless TMIL environments are carefully designed, these negative workplace responses to CSCW are likely to be duplicated in distance learning settings.

Some people strongly resist being forced to modify their interpersonal style to work (or learn) with a group using technology-mediated communication. Ultimately, part of why CSCW approaches increase team productivity and effectiveness is that they constrain the range and style of interaction, thereby minimizing miscommunications. However, people limited to a small set of responses may view such systems as ethically "facist" and strongly oppose their usage (23). Similarly, if the positive consequences of TMIL are to outweigh its negative side-effects, developers must strike an appropriate balance between constraining individual flexibility and providing a common group framework.

Just because a device is technologically and economically feasible does not mean that it will be used. The lack of demand for picture-phones is a classic example of how people will not adopt a feature they perceive as eroding an attractive attribute of a technology: Users don't want to get dressed up to talk on the telephone, they often want their facial expressions hidden, and they may choose to secretly simultaneously conduct another activity while appearing to be engrossed in (to them) a boring conversation. To be adopted, enhancements to existing distance learning technologies must be incremental, as tailorable by users as possible, and allow a range of alternative communications options.

CSCW researchers are well aware of the concerns about affective and social consequences just discussed, and their work reflects the synthesis of a number of fields (computer science, economics, cognitive science, sociology, anthropology, education, psychology) in addressing these issues. For those interested in a recent overview of CSCW, Irene Greif's edited compilation of articles is an excellent starting point (24). Ideas from CSCW should be very valuable in helping distance learning developers not "reinvent the wheel" in adopting new functionalities.

Ultimately, whether TMIL creates a global village for learning or an unattractive world of weakened emotional bonds and social relationships depends on our actions over the next few years. A negative scenario for virtual environments and artificial realities is certainly plausible; an excellent example is William Gibson's novel Neuromancer (25), which has spawned an entire genre

("cyberpunks") in science fiction. However, if we think through all the consequences of our design decisions and carefully monitor shifts in interpersonal interaction as they emerge, TMIL can be a very powerful tool for improving the quality of education.

CONCLUSION

This study describes how our present delivery of instruction over distance could become an even more powerful and useful educational medium through incorporating ideas from cooperative learning and computer-supported cooperative work. Today, leading-edge approaches to distance learning are used in selective situations to overcome problems that conventional instruction cannot address: scale (not enough students in a single location), rarity (an instructional specialty not locally available), and learning style (visual, emotionally muted). Its current conceptual challenges center on how this medium is different than a traditional classroom: visual rather than textual and auditory, scaled-down in its affect, able to convey complex cognitive material through multiple representations.

As distance learning evolves to technology-mediated interactive learning, it will become the preferred delivery system for certain types of instruction, rather than a fall-back approach to be used when conventional teaching strategies are not feasible. Distance learning classrooms can be designed to have a wider, deeper range of student skills than a local site could offer; a higher quality teacher than a single district could afford; and greater opportunities for students to interact than traditional single-classroom settings. By overcoming pupils' segregation into homogeneous enclaves, distance learning can enhance pluralism to prepare Americans for competition in the world marketplace. All educational institutions will prepare students adept at distanced interaction, for skills of collaboration with remote team members will be as central to the future American workplace as learning to perform structured tasks quickly was during the early stages of the industrial revolution. Students' learning environments will expand from the classroom to the world and from individual insight to collective intelligence.

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